On the Life-History of a New *Monophlebus* from India, with a Note on that of a *Vedalia* predaceous upon it. With a few Remarks on the *Monophlebinæ* of the Indian Region.

By E. P. Stebbing, F.L.S., F.E.S.

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(Plates 16–18.)

Part I.—*Remarks on the Monophlebinæ of the Indian Region.*

The *Monophlebinæ*, a subfamily of the Coccidæ, are a group of scale-insects about whose habits little until recently was known in India. In fact, up to 1901 but five species of the genus *Monophlebus* had been recorded from the Indian Region, and of this number four were described from the male insect alone, the females being still unknown. The discovery by the writer in 1901 of both the males and females of two new species was therefore of some interest and importance, but what is perhaps of equal value is that the life-history of one of them has been to some degree worked out, and its habits during one portion of its existence carefully and accurately noted. The species discovered in 1901 were sent to Mr. E. Ernest Green, Government Entomologist, Ceylon. Two were respectively named by him *Monophlebus Stebbingi* and *M. Dalbergiæ*, whilst a third, of which the females only had been procured, was provisionally named *M. Tectonæ*, the material proving insufficient for correct identification. In the following year further forms of this genus were discovered. One, of which both male and female were procured, was determined by Mr. Green as *M. Stebbingi*, var. *mangiferæ*. Others were discovered by the writer in Madras upon teak, *Anogeissus latifolia*, and *Terminalia tomentosa*. Only female specimens were taken, and these have yet to be dealt with, as also has a species which appears to be very numerous in Sind, but of which only the females have as yet been found, and another, reported as living upon the mango in Tirhoot and Dharbanga, in Bengal. It is a curious point about the genus that all the female insects yet discovered have a great resemblance to one another, being whitish oval thick scales. The determination of the species therefore requires the discovery of the males.

Present observations point to the subfamily confining itself to the woody portion of trees and shrubs only, feeding upon the leaves and green twigs in the younger larval stages. In forest-regions it can, as will be subsequently shown, increase in vast numbers, and is thus a source of considerable danger to the trees it infests. In this connection it will be profitable to consider shortly the food-plants and distribution of the at present known species of the genus in the Indian Region. We have seen that previously to 1901 but five species had been named; and four of these, *M. atripennis*, Klug, *M. Burmeisteri*, Westw., *M. Leachii*, Westw., and *M. Saundersi*, Westw., from the male insect only. The excessive feeding and consequent damage is the work of the female, the male being a minute two-winged insect in its adult form, with no mouth-parts. Consequently, in the case of four out of the five species known before 1901, the food-plants are unknown. The fifth bears the name *M. zeylanicus*, and was discovered by Green feeding upon the trunks of *Antidesma Bunius* at Punduloya in Ceylon. Of the three species (one at present doubtful) added in 1901, *M. Stebbingi*, whose life-history, so far as at present known, is treated of in this paper, lives upon the woody branches of the Sâl-tree (*Shorea robusta*, Gaertn.) in the Siwalik Hills and adjacent areas to the west of the Jumna River and east of the Ganges; *M. Dalbergiæ* upon those of the Sissu (*Dalbergia Sisso*, Roxb.) in the Sutlej Valley in the N.W. Himalayas; whilst *M. Tectonæ* (?) feeds upon the teak-tree (*Tectona grandis*, Linn.) in Berar and the Central Provinces. The additional species discovered in 1902 require further study. *M. Stebbingi* var. *mangiferæ* feeds upon mango trees in orchards in the Shalimar Gardens near Lahore and in the Public Garden at Bareilly. A species also lives upon mango in the Tirhoot State in N. Bengal, and at Dharbanga. This insect (or insects, if the Bengal one is a different species) is not unlikely to cause serious loss to fruit-growers when numerous, since the large amount of sap absorbed from the branches and twigs has an injurious effect upon the setting of the fruit *. Females of undetermined species have been obtained from the *Prosopis spicigera* in Sind (by Mr. F. Gleadow), and from teak,

* In a letter just received (12th May, 1903) from Lahore a correspondent informs me that the coccids are more plentiful than ever this year at Shalimar, and that the inflorescences of the mango trees have been seriously affected by their attacks.

Anogeissus latifolia, and *Terminalia tomentosa*, by the writer in the Coimbatore Forests of the Madras Presidency.

From the above notes it will be seen that the genus has apparently a fairly general distribution throughout the Indian Region, being, however, as yet unreported from Assam and Burma. The boundaries may be roughly taken to be as follows:—The Sutlej Valley at a point some 50–70 miles N.E. of Simla in the North-West Himalayas for the northern, with Punduloya in Ceylon as the southern limit, whilst on the west we have a species reported from Sind. The eastern boundary is the most vague. I have received specimens of *M. Stebbingi* from Philibhit, and the mango variety of this scale is to found at Bareilly. But since these insects were obtained, a *Monophlebus* has been procured from Tirhoot and Dharbanga, and this must be looked upon as the present eastern limit. I have myself little doubt, however, that this limit will soon be passed as our knowledge of the genus increases.

Part II.—*On the Life-History of* Monophlebus Stebbingi, *Green* (Indian Museum Notes, vol. viii. p. 100).

(Pl. **16.** figs. 1–13; Pl. **17.** fig. 1; Pl. **18.**)

After this brief summary of the information at present available on the known species and distribution of the genus *Monophlebus*, a more detailed consideration may be given to one of the species, *M. Stebbingi*, with regard to its life-history, portions of which the writer has had exceptional opportunities of studying.

Early in January 1901, whilst on tour in the Sâl Forests of the Siwaliks, soon after my arrival in Upper India, some minute little yellow specks upon the underside of Sâl-leaves were pointed out to me by Mr. J. W. Oliver, Director of the Imperial Forest School, Dehra Dun, as an insect, supposed to be an aphis or scale, which later in the year appeared in great numbers *. The yellow specks were the young larval forms of a *Monophlebus*, subsequently named by Green *M. Stebbingi*. From that date

* I found that this scale had been known for some years to Planters and Forest officers serving in the Dun, but no attempt had been made to study its life-history. A few specimens of the immature female had apparently been sent to the Indian Museum by Mr. F. Gleadow in 1900, and he had been told that they were immature forms of a *Monophlebus*, but much too small to do anything with. This was the position of affairs in January 1901.

onwards till the end of April, I watched the growth of the scales, sending mature specimens of the male and female (taken by myself personally in the forest) to Green at the end of April. The succeeding year I was able to study the insect again from the middle of January till the middle of May, whilst the following season I watched the younger stages from their first appearance in November until near the end of February. The insects were late in appearing in 1900–01, owing to wet cold weather, but were earlier by several weeks in the seasons of 1901–02 and 1902–03. During the last four or five years the weather seems to have been on the whole most favourable to the development of the pest, which has appeared in ever increasing numbers, and has spread into forests previously reported as free from it. In 1902 the attack was upon a very large scale, the woods over the infested areas literally swarming with the fat white female coccids. It was during this year that the predaceous *Vedalia* beetle was first noticed at work. During the past winter of 1902–3, the young scale again appeared numerously upon the leaves of the trees, and the long spell of intensely cold though excessively dry weather appeared to be favourable to the development of the young larvæ, which were very numerous up to the middle of February, when my observations ceased owing to a transfer to Calcutta.

As seen early in the cold weather (November), the insect is a minute little coccid covered with white woolly hair. It is to be found at this period on the leaves of the Sâl-tree. The little larva soon loses this hirsute covering, and is then yellow in colour, changing to an orange or yellow-brown. At this stage it is still less than 1·5 mm. in length. A fortnight later the brown colouring becomes more pronounced, the scale being then about 2·08 mm. in length, long-elliptical, convex dorsally, and flat beneath, with a longish proboscis, a pair of black antennæ, and three pairs of black legs. After a fourth period of fifteen days has elapsed, the larvæ are about 6·25 mm. in length, dark brown on the dorsal surface, changing to orange or pale canary-yellow in the older specimens; ventral surface canary-yellow; proboscis, antennæ, and legs black. There is a fringe of hairs round the margin (Pl. 16. fig. 2). This colouring remains much the same until the animal reaches maturity, but the whole of the upper surface becomes, when the scale is about half-grown, covered with a white mealy powder.

The male larva is not yet known. The male pupal case is small, dark brown in colour, elliptical, but with a curious fan-shaped flattened expanded portion at one end, rather like the caudal appendage of a fish. This pupal case would appear to be only the last larval chitinous covering, since the leg and antennal cases are attached to it (Pl. 16. figs. 3 & 4). The pupal skin ruptures at the anterior end—the male insect crawling out of the elliptical opening thus produced. The length of the pupal case is 4 to 4·2 mm. The perfect insect is a small black-winged fly. Both sexes mature in April. Green describes the male and female insects as follows:—

"*Monophlebus Stebbingi*, Green. Indian Museum Notes, viii. p. 100.

"Adult ♀ [Pl. 16. figs. 5, 6]. Robust. Margins somewhat flattened and forming a distinct lateral keel; median dorsal area tumescent; division of segments well-defined. Colour slaty-grey, thickly dotted with white mealy powder. Legs and antennæ black. Margin with irregular fringe of longish black hair; the whole ventral surface covered with a short pubescence, denser on the margin and intersegmental regions. Both dorsum and ventral surface with numerous circular pores, some with single, some with double orifice, the orifices guarded by small raised points. Antenna with eight joints: first seven subequal in length, third sometimes longer, eighth longer than previous two together; all the joints with many blackish hairs. Legs stout, spiny: tarsus short, scarcely half the length of the tibia: claw long and stout, with a pair of simple hair-like digitules. Anal aperture on dorsum, at some distance from extremity, surrounded by a group of stout hairs. Length of early adult females (taken *in coitû* with the male) 8·50 mm. Breadth 4·50 mm. Older examples attain a considerably larger size. The largest I have examined measures 13 mm. by 8·50 mm., and it is possible that others may exceed these dimensions.*

"Adult ♂ [Pl. 16. fig. 7]. Dull red: notal and sternal plates black: the whole body dusted with mealy powder, giving it a pruinose appearance; a lunate pale patch in the centre of the mesonotum and a pale space between the mesonotal plates and the scutellum. Legs and antennæ black: wings fuscous, corrugated, with two white creases, one on each side of the discal

* The writer has specimens in his possession of as much as 18·75 mm. and over.

nervure. Halteres with five stout hooked bristles at extremity. Antennæ 10-jointed: 3rd–9th each with three nodes, 10th with four nodes; each node with a whorl of long hairs. Eyes large, compound; a single ocellus on the dorsal surface at inner margin of each eye. Abdomen with three elongate fleshy hairy processes on each side; the first shortest, the third longest. Genital sheath not projecting beyond the posterior margin of abdomen: penis usually partially everted, densely clothed with short reversed hairs. Length 5 mm. Expanse 11·50 mm."

A noteworthy characteristic of the female is the great difference in size of the individuals, and it would appear that it becomes sexually mature before reaching its full dimensions.

Egg (Pl. 16. fig. 1): small, dry, shining, oval-elliptical. Colour pink: length 1 mm.

When they first appear the minute scales are to be found on the under surface of the Sâl-leaves, and very shortly after hatching they cluster round the mid and other ribs of the leaf, either on the upper or under surface, but more usually on the latter, their probosces being buried in the tissues of the rib. When they have somewhat increased in size, and after losing the white hair with which they commence life, they confine themselves to the mid-rib alone, and then undergo a first moult. From the first the coccids exude a sticky sugary liquid which coats the leaves, and the little white papery skins of this first moult remain stuck by means of this to the leaves, and thus serve to attract the eye to the presence of the insect. The female larva appears to spend from 6 to 8 weeks feeding in this way upon the leaves. The scale is not stationary, but moves about over the leaf and from leaf to leaf. It almost certainly gets spread by the agency of other insects and spiders, and probably also by birds. The sticky exudation doubtless greatly facilitates this dispersion, since animals crawling over or fluttering amongst the leaves and twigs of badly infested trees would unavoidably take up to a certain extent portions of it, and with it a few of the young scales. The habit which this insect possesses, in common with most scale-insects, of crawling over every obstacle in its path, even over its predaceous enemies, which it seems quite unable to recognize, doubtless also helps in its diffusion.

After from 6 to 8 weeks spent upon the leaves, the period depending upon the favourableness or otherwise of the season, the young scale descends to the twigs, and during the rest of its

developing-stage it lives and feeds upon these. Soon after this change of position a further moult is gone through. Moulting takes place as follows :—The skin becomes ruptured anteriorly at a horizontal line of cleavage just above the insertion of the antennæ, the split extending to the first segment of the thorax on either side. At the same time, from a central point in this horizontal line of cleavage a further rupture occurs in a vertical plane, the split reaching a median point in the posterior edge of the metathorax dorsally (Pl. 16. fig. 8), and to the centre of the coxæ of the anterior pair of legs ventrally (Pl. 16. fig. 9). This cleavage having taken place in the chitinous covering, the insect crawls slowly out. Consequently, as a reference to fig. 9 will show, on the under surface of the old discarded skin the black empty leg and antennal cases are to be found. These cast skins remain gummed by the sugary secretion to the twigs (Pl. 16. fig. 11), the insects moving off to fresh ones.

When numerous, the young coccids collect in clusters round the twigs, covering thickly the thinner barked ones (Pl. 16. fig. 10). They are also to be found at wounds on older and thicker branches. When they first quit the leaves the scales are about 3·12 mm. in length. From then onwards their growth becomes more rapid, at least one more casting of the skin takes place, and they mature toward the end of March or middle of April. They change their position and walk about over the trees more often as they begin to reach their full development. It is after this last moult that they acquire the white powdery covering, and if the insect is at all numerous the twigs and branches will be seen to be closely encircled with serried white masses, often for a length of 6–9 inches, of the coccids, giving them the appearance of being encrusted with snow, the scales lying one upon the other, often one tipped up at an angle and resting upon a companion below as depicted in Pl. 17. fig. 1 and Pl. 18, *a*. Each has its proboscis firmly imbedded in the cambium layer, and spends its time sucking in the sap of the branch. I have mentioned that the insects are active throughout life and march about over the trees, and this habit is perhaps more especially noticeable in their later stages of development, when their whitening appearance renders them more conspicuous. When mature, they are to be seen crawling down the trunks of the Sâl-trees, these latter being often thickly dotted with the fat white scales.

I have alluded to the sugary excretion. This is poured out very copiously during the whole of the developing-period up to the time of fertilization, soon after which the scales cease feeding. This sticky sugary liquid, which rapidly dries in the hot sun, covers leaves and twigs, clogging up the stomata, runs down the branches, and drips to the ground below in enormous quantities when the insects are plentiful. This feature will be referred to later on as it is of some importance.

The male larva has not yet been found. I was successful in discovering what undoubtedly were pupal cases. In some instances dead male insects, half emerged from the cases, were secured. They were found in the interstices of the rough bark of a felled Sâl-tree, protected by being placed on the portion lying adjacent to the ground. The male insect matures about the middle of March in favourable seasons, and may be seen on the wing for some weeks, possibly as long as a month, until the female scales have all or almost all matured. It is by no means so abundant as the female, and later it pairs with several of these. It is a very active creature, flying about over the serried masses of the coccids or walking over the backs of the thick clusters. Its method of fertilizing the female is as follows:—The male flies or walks lightly up to the female scale, which is probably engaged in sucking up the sap of a twig, alights or climbs on to her dorsal surface, and then forces itself under her between her ventral surface and the twig. It then inserts its anal appendages into the anal aperture of the female, thus becoming attached to her, and remains so attached even if she moves about. When *in coitû* the male may be facing in the opposite direction to the female, lying upon its back so to speak, or it may curve its body up and over the anal segment, clinging with its anterior legs to the dorsal surface of the last segments of the female scale. It remains attached usually for several minutes.

After fertilization the female scales appear to cease feeding, leave the twigs, and march down the trees in search of convenient places to oviposit. It is at this stage more especially that badly-infested forests appear to be alive with the insects—trees, undergrowth, soil, stones, and dead fallen leaves being covered with the crawling coccids. A few days would appear to suffice for the eggs to develop within the body of the female; the females oviposit during the latter part of March and on through April, the actual period depending upon the favour-

ableness or otherwise of the year to insect life. Before the eggs are actually extruded from the body of the female, the posterior ventral segments are seen to be developing a white woolly hair. This increases in amount, especially towards the anal extremity, and this white woolly mass serves as a second covering for the eggs. At first this white cottony material is quite short and, looked at from the dorsal aspect of the insect, it is seen to project only a little way beyond the tip of the abdomen. It, however, rapidly increases in amount until the insect appears to have a small wad or ball of pulled-out cotton-wool attached to its abdominal segments, protruding all round from the ventral surfaces of the three posterior segments. A closer examination of this cottony mass will show that it really surrounds a fine cotton sac which encloses the eggs (Pl. 16. figs. 12 & 13). Countings I have made of these latter show that a female lays between 400 and 450 eggs. The greatest number counted in a sac was 478. Before actually extruding the sac from the body, the scale leaves the upper part of the tree and searches out some nook or cranny beneath the rough bark, or a sheltered spot beneath stones, refuse wood, &c., and conceals herself. After the eggs in the cottony sac have been extruded from the body, little but the skin remains, the insect dies, and the dead shrivelled skin remains as a partial covering to the eggs. Egg-laying would appear to last from a fortnight to three weeks, after which both the male and female insects disappear from the forest. I have noted that the eggs at times are not deposited in particularly sheltered places, and there can be little doubt, I think, that they get blown about a good deal by the wind, and carried about by hairy spiders, large lizards, the feathers of birds, and in the hair of mammals such as deer, rodents, &c.

There are one or two remarkable features resulting from the presence of this insect in large numbers in a forest. One is the enormous exudations secreted by the insects. They appear to be little more than siphons, and their excretions cover the branches and trunks of the trees and undergrowth and stones, leaves, &c. upon the ground beneath with a coating of a sticky nature, which dries like varnish in the sun. So great is the amount of sap taken from the trees, that in the silence of the forest these exudations can be heard dropping from the tall trees like raindrops after a smart shower. One's clothes and exposed

parts of the body become covered with the unpleasant sticky liquid, and half-an-hour's walk through an infested forest reduces one to a condition of great discomfort. This state of affairs, in years favourable to the increase of the insect, may last from early in January until well on into April.

Another peculiarity about the female is its power of dropping from great heights without harming itself. The smart pat of scales falling from the branches of the tallest trees is to be continually heard on all sides. They appear generally to fall on to their ventral surface, and out of numbers examined I never found one instance in which the scale appeared to have suffered injury or even inconvenience from its great drop. Whether the coccids allow themselves purposely to fall, or whether they get pushed off the branches by companions, I am unable to say, but their habit of feeding so close together would certainly cause their displacement at times. This point is of importance, since it undoubtedly helps in spreading the insect, which is by no means a fast walker.

A third interesting point—one common to all great increases in insect pests, but perhaps especially remarkable in the case of this very noticeable white scale—is the change that a few days will make in the aspect of an infested area. The contrast which eight days will show in this particular case is wonderful. On the one day when the attack is reaching or has reached its culminating point, the forest may be seen to be alive with the insects. Eight days afterwards a scattered few may still be seen crawling about, but the great mass have disappeared, and one seems to be in quite a different locality. The female scales, however, can never be said entirely to disappear from the area. It is generally possible to find a few right on through the months of June, July, August, and September. These may be unfertilized females which developed very late, but I have not been able to account for them satisfactorily. Further, in 1902, after the insects had practically completely disappeared from the forest, I found in several places some young scales, canary-yellow to brown in colour, and from 2·08 to 3·12 mm. in length—in fact, at the age and size usually found in late January and early February. I have not been able to account for finding these.

I have not yet discovered the insect which develops from the eggs laid in such numbers by the female scales. There may be

a second stage in the life-history of the insects, as in the case of *M. zeylanicus* of Ceylon, but this has yet to be proved. The branches of the Sâl-trees in the forests which are infested by these coccids have curious knotty swellings on them, which I have never seen elsewhere in India upon this tree, and this may be due to a second subcortical stage of the *Monophlebus*. My observations on this point are, however, not as yet complete.

Periodicity of Attack.—This coccid has been known for some years in the Siwalik area, but it is only since 1899 that attention has been seriously drawn to it. Each year since then it has steadily increased in numbers and spread outwards, until in 1902 there was no part of the Siwalik area between the Jumna and Ganges rivers that was not affected, and it was to be found both west and east of this tract.

Distribution.—This scale has at present only been reported from Northern India. Its known habitat is (beginning from the west) the small Kalesar forest situated on the western bank of the Jumna river in the plains at the foot of the Himalayas. From here the insect crosses the Jumna, and is found throughout the Sâl areas of the Dehra Dun plateau and the Siwalik range of hills, on both north and south aspects, as far as the Ganges river on the east. It is also plentiful in the patches of Sâl forest between the Ganges and Jumna rivers, which extend into the plains south of the Siwalik range. To the east of the Ganges its distribution has not as yet been fully determined. I have specimens (identified by myself) and reports of it from the Garhwal and Philibhit districts. It is also plentiful in the Kheri Sâl-forests of Oudh. The area which it is at present known to infest may therefore be taken as a strip of country extending some 300 miles from west to east, and 100 miles wide in a north and south direction on its eastern limit, tailing-off to a 10-mile strip at its western boundary. I have, however, little doubt that it will be found to the east of its at present reported limit.

Over all the infested area this coccid, from its excessive vitality and the great numbers of eggs which the female is capable of laying, must be looked upon as a serious pest to the Sâl-tree, one of the most valuable of the trees of India, distributed over a large tract of the continent. It therefore follows that the careful study of the life-history and distribution of the

pest is of the first importance, in order that an endeavour may be made to prevent its spreading into Sál areas at present free from it, and that species of like character, in the event of their only too probable occurrence, may be dealt with in the light of acquired experience.

Present observations show that the female is the chief aggressor; but it must be borne in mind that it has yet to be proved that there is not a second subcortical stage which is likely to do much injury to the trees. The damage arising is due to the heavy loss of sap the trees suffer owing to the continual tapping for several months on end. In the cold weather months from November to February this is perhaps not serious, since the insect is then feeding upon the old leaves. The sap is down and growth has probably ceased, and the clogging of the stomata by the excreted fluid is perhaps the most serious effect at this period. The injury really begins to become acute when the coccid has got down to the twigs. The heavy loss of sap resulting from its attacks at this stage cannot be otherwise than most serious in months when the tree requires all its vitality to enable the spring leaf-buds to develop perfectly and the flower-heads fully to mature. It is just at this period, the most dangerous one for the tree, that the attack of the *Monophlebus* is culminating. Experiments have been commenced with the object of discovering:

(i.) The effect upon the development of the spring crop of leaves of a bad infestation by the coccids;

(ii.) The effect of the same upon the maturing and vitality of the seeds.

The attacks are more severe in dry years, since the scale is then in greater abundance.

The damage attributable to the insect may be summarized as follows:—

(*a*) The clogging-up of the stomata and pores of the leaves and twigs by the sugary secretion. This envelops leaves and twigs, &c. with a sticky film which dries in the sun, giving them the appearance of having been varnished. If the year is a wet one the film is rapidly dissolved off by the rain, but in dry seasons it remains for several months *in situ*.

(*b*) Twigs and small branches dry up and die off under the excessive tapping. This latter occurring in the spring has a most serious effect upon the development of the spring crop of

leaves, and upon the flower-panicles which open in April. The production of the seed is thus probably considerably interfered with.

(*c*) The damage caused to young saplings is perhaps even more serious, as the insects congregate round the leading shoot and the upper side ones, extending down each for several inches in a serried encircling mass. The leading shoot is often killed, and side ones taking its place follow suit, and the young sapling takes on a crooked habit of growth most detrimental to its future value as a forest tree.

Pl. 18, *a*, shows the female scales collected on a young sapling in this manner.

It may be interesting to note that in the 1901 attack the scale was accompanied over a portion of the Dun Sâl areas by the larva of *Boarmia selenaria*, Hübn., a geometrid moth. This larva was in thousands, and devoured the Sâl-leaves in the most voracious manner. In fact all the green parts of the tree—leaves, buds, the green shoots of the year, together with the white inflorescences—were eaten down, nothing but the blackish last year's growth being left. The larvæ (Pl. 18, *b*, *b*) can be seen in characteristic attitudes on the upper part of the tree, which they had stripped bare of all green growth. The scales are collected lower down upon the leading shoot in a serried mass.

In the sugary secretion emitted by the scales, a black fungus develops and envelops the leaves and twigs, and doubtless helps further to clog up the stomata. Dr. Butler, Cryptogamic Botanist to the Government of India, has informed me that much of this fungus belongs to the genus *Capnodium*, which is almost always associated with scale-insects. The *Capnodium* was present in three other forms:—

(a) *Cladosporium*, Link (syn. *Fumago*, Pers.).

(b) *Triposporium* sp.,

(c) *Coniothecium* sp.;

these three being conidial stages in various species of *Capnodium*.

Part III.—*On the Life-History of* Vedalia Guerinii, *Crotch, predaceous upon* M. Stebbingi, *Green.*

Vedalia Guerinii, *Crotch, Rev. Coccinell.* p. 282 (Lond. 1874). (Pl. 17. figs. 2–9.)

The following are my descriptions of the larva and pupa, made from living specimens:—

Larva.—When young the larva is black in colour, with three pairs of stout thoracic legs. During its first two moults it appears to retain this colour, being long and narrow with a well-developed head and mouth-parts. As it grows in size it becomes more oval, and the colour changes to white and black or reddish with white markings or a greyish purple. The grub is often covered with a certain amount of the white powdery material which covers the older stages of the *Monophlebus* upon which it feeds. The young larva has a number of tubercles upon its dorsal surface. When full-grown the larva is 12·5 mm. long, and has a well-developed head, which is narrower than the ten segments of the body which follow it. Of these latter, the middle ones are the broadest, the grub tapering to each end. On each of these ten segments there are four dorsal tubercles, two on each side, thus giving four rows of dorsal tubercles. These segments are also fringed on either side by projecting teeth-like processes resembling a saw-edge, giving the insect a serrate appearance at the sides. The last two segments make up the dark reddish-black pad-like apparatus which terminates the body, the end of which forms a kind of sucker which is very adhesive and enables the larva to cling to the smoothest bark by its means. The sucker is used in feeding, and also in fixing itself permanently to a twig or leaf before changing to the pupal state (Pl. 17. fig. 4 *a*). The arrangement of the segments makes the body extremely pliable, and the grub can roll itself up almost into a ball. The ventral surface is coloured like the dorsal aspect, but has no tubercles. Just before pupating the larva often changes from the white and black or greyish-purple colour to a brick-red.

Pupa.—When about to pupate, the larva attaches itself either to the upper or under surface of a leaf or to a twig or rough bark by means of the posterior adhesive pad, its body projecting at an angle from the point of attachment, and assuming a curved

position, the dorsal surface being convex, ventral concave (fig. 4*a*). The larva remains in this position for about 24 hours, and then the outer skin splits dorsally from the anterior end to the posterior portion of the 10th segment, and the skin gets drawn or shrivels back on either side, and the bright red, almost spherical, pupa is disclosed (figs. 4 *b* & 5). The pupa, nestling in the surrounding purple and white speckled old larva-skin, looks not unlike a small wild strawberry fruit sessile amongst the leaves. In the crimson pupa the two small black eyes of the future beetle, the developing wings, and dorsal segmental divisions of the abdomen can be distinctly seen under the brightly coloured skin. The posterior segment of the future beetle is nearest to the point of attachment of the pupa, so that when the adult coccinellid is ready to emerge, the skin splits dorsally and ventrally at the anterior end of the pupa, and the beetle crawls out. Size 6·25 mm. The colour varies from bright to dull red, crimson, or orange-red.

For the imago, *vide* Crotch's description in his 'Revision of the *Coccinellidæ*,' p. 282 (1874).

In both its larval and adult stages this *Vedalia* preys upon the coccid *M. Stebbingi*.

It was found in its larval, pupal, and imago forms in large numbers in the Siwalik Forest in April 1902.

The exact period passed in the larval stage has yet to be observed, but the grubs in that year commenced pupating towards the end of March, and continued to do so till the end of April. Eight to nine days appear to be the usual period spent in the pupal stage. Larvæ pupating on the 16th April issued on the 24th and 25th of the month, and numerous other individuals bred out showed this period to be fairly constant. The beetle passes some days, perhaps as much as a fortnight, feeding upon the scales before pairing and ovipositing. The male adult dies within 24 hours of fertilizing the female; this latter then apparently seeks out a place of concealment before depositing her eggs. These eggs have not yet been discovered, though dead beetles have often been found in interstices of bark, beneath stone and débris on the ground, &c., near the dead shrivelled skins and cottony egg-sacs of the *Monophlebus*. It would appear probable that they lay their eggs in the places wherein those of the coccids are deposited.

The larva is a very active grub, and when in search of its

prey it is to be found running at a great pace over the leaves, twigs, and bark of the trees. During this portion of its existence the insect is not gregarious. The larva is a voracious feeder, and preys upon the large white succulent female scales with the greatest avidity. Its method of operation is as follows:—

On perceiving a scale it rushes at it with great impetuosity and at once fixes its mouth-parts in the soft skin, often on the ventral surface between the first and second pairs of legs and a little to one side. At the same moment it attaches itself to the twig by its terminal adhesive pad. The scale at first makes no movement, but after the lapse of a minute or two ceases feeding (if it were engaged in that operation at the time of attack) and commences slowly moving its antennæ and legs, at first lazily, as is its habit when crawling about, but later more vigorously. As it does this, a bright canary-yellow stream of liquid flows down from its body onto the twig. This exudation from the wound continues for about three to four minutes, after which it ceases, the rest of the material being absorbed by the larva, who has by now his mouth-parts firmly fixed into the coccid. This latter now makes vigorous though unwieldy attempts to get away, and being so much larger than the grub, often even as much as thrice its size, it at times stretches out its enemy to its full length, the segments under the tension becoming much elongated. The latter, however, keeps its position on the twig by means of its sucker-pad with the greatest ease. Practically only the mouth, first pair of legs, and sucker-pad are made use of, the first being buried in the body of its victim, the second clasped round it, the third attached to the twig. The 2nd and 3rd pairs of legs are held backwards almost against the ventral surface of the body (fig. 7). Under this sucking process the formerly robust powdery-white succulent scale shrinks gradually to a shrivelled, wizened, dried-up, yellowish-brown skin. The larva's mouth consists of a tube terminating in a swollen knob where it joins the head, the latter being greenish-yellow in colour. This probably acts in the nature of a sucker as well, since it exerts considerable leverage upon the scale. Larvæ watched feeding have spent between eight and nine hours clinging to and sucking a scale, at the end of the period only the shrivelled skin remaining. The vitality of the *Monophlebus* is very great, since at the end of six to seven hours

of this continued tapping process on the part of the grub it is still alive, slowly moving its legs and antennæ. This object-lesson in the insect world has to be seen and watched to be properly appreciated. At first sight it would appear incredible that such a small larva as the *Vedalia* should be capable of entirely absorbing the contents of an insect of the size of the *Monophlebus*, and the curious point about this absorption is that the grub shows little signs of having assimilated this large amount of food-material. There is very little distension of the segments, and I could observe very little excretion taking place during or after this heavy meal. The grub is very active, and must be possessed of an exceedingly rapid digestive system. It would be of great interest to study its digestive organs with the object of discovering whether it gets rid of excreta in any manner through the skin.

I have mentioned the great voracity of the grub, and my observations led me to discover that it has cannibalistic propensities, for I found it preying upon pupæ of its own species. This may have been due to a shortness in the food-supply. It dashes on the pupa with its usual impetuosity, seizes it round the crimson spherical portion with its two anterior legs, fixes its mouth-parts into the soft tissues beneath the skin, and sucks out the contents, leaving the crimson skin empty in a very short time (fig. 8 *a*).

The larva is parasitised by a hymenopterous or dipterous fly. Larvæ in the first stage of pupation, *i. e.* before the skin splits down disclosing the crimson pupa, were noticed to have a dried appearance. An examination showed several, as many as five in some instances, small round holes, evidently the exit-holes of a parasite (fig. 8 *b*). This insect, while it decreases the number of future beetles, does not appear to prevent the larva destroying a number of scales, since it has strength to pupate before succumbing to the parasite. I have not as yet discovered this parasite.

When about to pupate the *Vedalia* grub becomes gregarious, the pupæ being often found in numbers close together on the upper or under side of leaves or twigs &c. This habit was too marked to have been due to accident. The beetles are very gregarious. During the heat of the day, when they do not feed, they are to be found in large numbers collected close together

on the underside of leaves—Sâl, *Bauhinia*, and other large leaves being those usually affected. The adults also feed upon the female *Monophlebus*, attacking them in a similar manner to that of the grubs and anywhere on their dorsal or ventral surfaces (fig. 9). They do not, so far as my observations showed, fly up and alight upon a scale, but usually crawl up to it and then make a short rush. In feeding they pierce through the skin, and a drop or two of the yellow liquid comes out, but never a stream. They do not kill their host outright, as they appear to be full-fed in half an hour (and often do not remain more than five to ten minutes), by which time they have absorbed but a small quantity of the body-contents. Whilst the beetle is feeding upon it, the scale either continues to remain with its beak buried in the tissues of the Sâl-twig or it may move about with the beetle attached to it, but it does not appear to be inconvenienced to any great extent, and only shows signs of feeling when the beetle first pierces through the skin. The scales would, however, appear to be killed off in time, or to have their vitality greatly reduced, through this constant tapping by different beetles. Individuals which have been so tapped show numbers of small white and yellow spots, the places at which the beetles have pierced them. They lose their fresh white powdery appearance, become much shrivelled, are dirty brown or whity-black in colour, and move about very slowly. It is probable that those which do not die under this constant sapping of their body-contents are so reduced in vitality that their egg-laying capacity becomes considerably impaired, and even if eggs are laid, their fertility is probably doubtful. The female *Vedalia* would appear to commence oviposition at about the same time as the *Monophlebus*.

A careful study of this attack showed me that the *Vedalia* did not begin to multiply in any serious proportions until the female scale had undergone its third moult. The numerous empty white papery skins of this moult, attached by the sticky secretion in large numbers to every twig and branch, were evidence of the fact that the coccid had reached this stage of development before its decimation commenced. These skins remained *in situ* upon the branches for several weeks owing to the exceptionally dry year experienced in 1902, practically no rain of importance falling during this period. A single heavy thunder-

storm, such as are usually experienced at that season, would at once dissolve the sticky excretion covering the branches and remove all evidence of the preceding moults, and thus the state of affairs in progress would not be so clearly decipherable as it was in the year in question. The forests were a truly remarkable sight about the middle of April. Larvæ, pupæ, and adults of the *Vedalia* were everywhere: the former running agilely over the trees in quest of their prey; the pupæ being collected in numbers on leaves and twigs, more especially perhaps on the former; whilst the large leaves of the trees were weighed down by the red masses of the beetles clinging to their under surfaces during the heat of the day, as these latter only feed in the early morning and evening. On every side also were dried shrivelled skins of the sucked-out scales, gummed to the branches or bark of the trees, stuck in the interstices of the bark of the latter, or littering the ground amongst the dead leaves, &c. Away aloft the crowns of the great Sâl-trees appeared to have their extremities encrusted with snow from the numbers of the scales clinging to and feeding on the sap of their twigs and smaller branches, and this incrustation was repeated on the branches of the smaller trees and saplings, whilst the crawling coccids invaded every corner of one's tent and covered the leaf-littered ground without.

DESCRIPTION OF THE PLATES.

Plate 16.

Monophlebus Stebbingi, Green.

Fig. 1. Eggs.
2. Young ♀ scale-insect, dorsal view.
3. Side view of ♂ pupal case.
4. Ventral view of ♂ pupal case.
5. Full-grown ♀ scale, dorsal view.
6. „ „ side view.
7. Winged ♂ insect.
8. Cast skin of immature ♀, dorsal view.
9. „ „ ventral view.
10. Immature ♀ feeding upon a young Sâl-twig.
11. Cast skins of immature ♀ attached by the sugary secretion to a Sâl-branch.
12. Ventral view of ♀ with cottony egg-sac and eggs.
13. Dorsal view of ♀ with cottony egg-sac.

Plate 17.

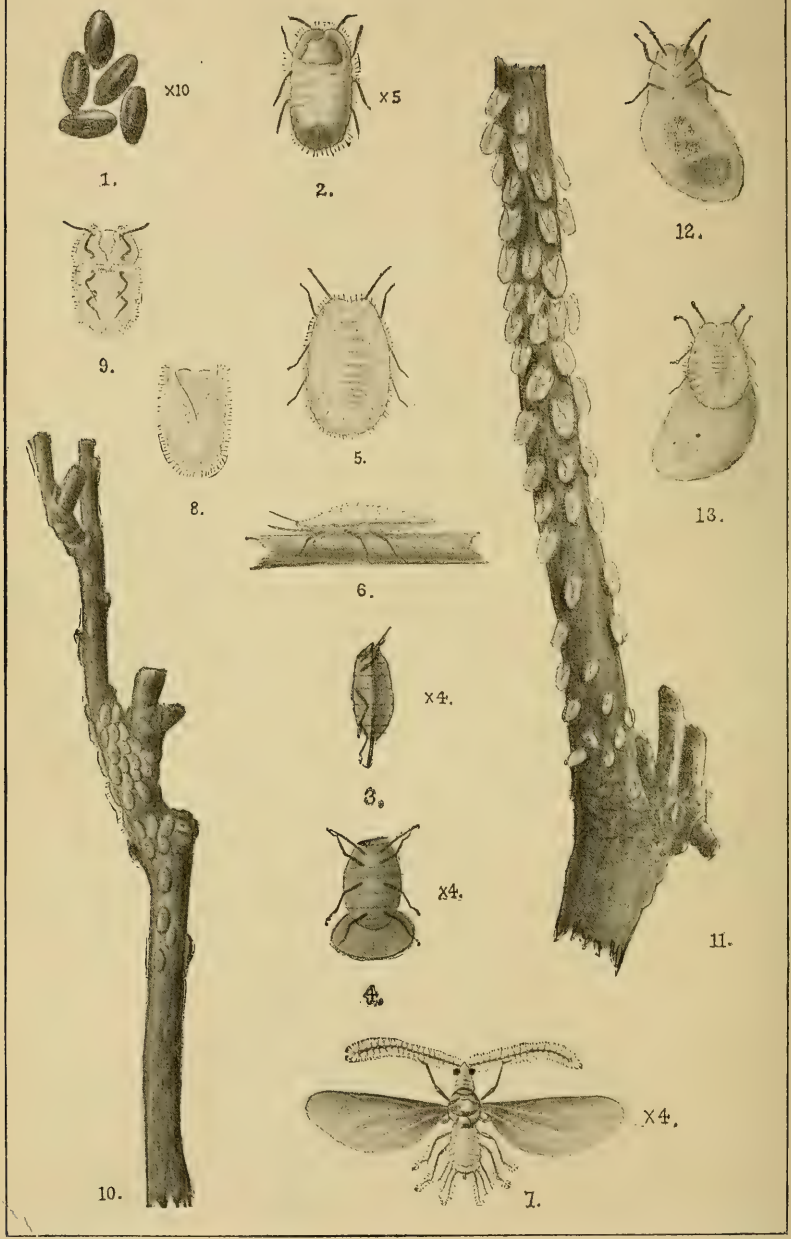
M. Stebbingi, Green, and *Vedalia Guerinii*, Crotch.

Fig. 1. Sâl-branch with fully mature ♀ scales feeding (from a drawing by Author).
2. Larva of *Vedalia Guerinii*, dorsal view.
3. „ „ side view.
4. Sâl-twig with (*a*) pupating larva, (*b*) sessile pupa, upon it.
5. Pupa of *V. Guerinii*, sessile, upon a Sâl-leaf.
6. Beetle.
7. *Vedalia* larva attacking ♀ *Monophlebus*-scale.
8. Sâl-twig with (*a*) *Vedalia* pupal skin after having been attacked by *Vedalia* larva, (*b*) larval skin after attacks of parasites.
9. *Vedalia* beetle attacking ♀ *Monophlebus*-scale.

Plate 18.

Upper portion of a Sâl (*Shorea robusta*) sapling, showing the attacks of *Monophlebus Stebbingi*, Green (below), and of the larvæ of *Boarmia selenaria*, Hübn. (above). From a photograph by Mr. R. C. Milward, I.F.S.

Note.—Small numbers against the figures give the enlargement. Unfortunately all the Plates, in reproduction, had to be reduced by about $\frac{1}{5}$th. This reduction will therefore have to be allowed for to obtain the true sizes of the figures shown.



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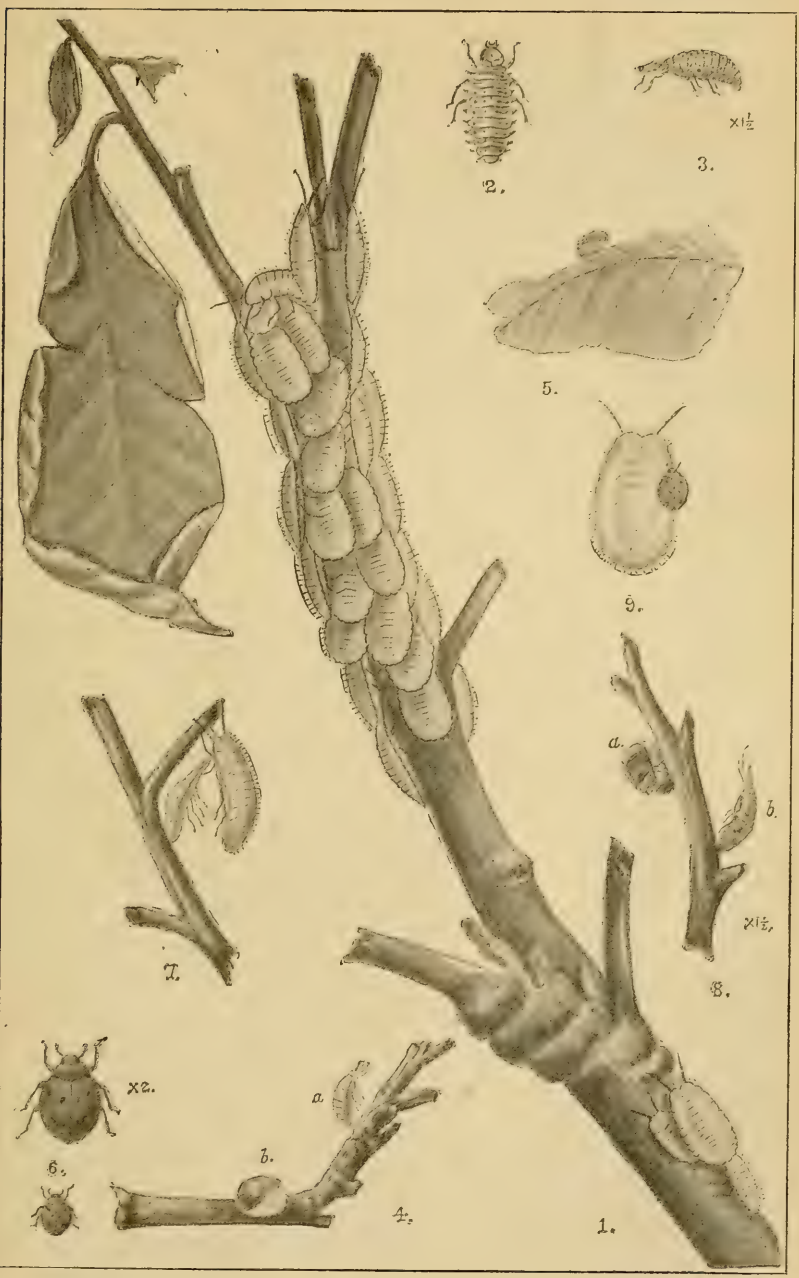
MONOPHLEBUS STEBBINGI, Green.



S. B. Mondul, del. T. P. Collings, photosc.

MONOPHLEBUS STEBBINGI, Green, and
VEDALIA GUERINII, Crotch.

R. C. Milward, photo.
S. B. Mondul, del.

T. P. Collings, photosc

MONOPHLEBUS STEBBINGI, and
BOARMIA SELENARIA, Hübn.